METHOD AND APPARATUS FOR PRODUCTION OF NONWOVEN WEBS

Field of the Invention

The present invention relates to a method for forming nonwoven webs and an apparatus for forming such webs.

Background of the Invention

Many of the personal care products, medical care garments and products, protective wear garments, mortuary and veterinary products in use today are partially or wholly constructed of nonwoven web materials. Examples of such products include, but are not limited to, consumer and professional medical and health care products such as surgical drapes, gowns and bandages, protective workwear garments such as coveralls and lab coats, and infant, child and adult personal care absorbent products such as diapers, training pants, swimwear, incontinence garments and pads, sanitary napkins, wipes and the like. For these applications nonwoven fibrous webs provide tactile, comfort and aesthetic properties which can approach those of traditional woven or knitted cloth materials. Nonwoven web materials are also widely utilized as filtration media for both liquid and gas or air filtration applications since they can be formed into a filter mesh of fine fibers having a low average pore size suitable for trapping particulate matter while still having a low pressure drop across the mesh.

Nonwoven web materials have a physical structure of individual fibers or filaments which are interlaid in a generally random manner rather than in a regular, identifiable manner as in knitted or woven fabrics. The fibers may be continuous or discontinuous, and are frequently produced from thermoplastic polymer or copolymer resins from the general classes of polyolefins, polyesters and polyamides, as well as numerous other polymers. Blends of polymers or conjugate multicomponent fibers may also be employed. Nonwoven fibrous webs formed by melt extrusion processes such as spunbonding and meltblowing, as well as those formed by dry-laying processes such as carding or air-laying of staple fibers are well known in the art. In addition, nonwoven fabrics may be used in composite materials in conjunction with other nonwoven layers as in a spunbond/meltblown (SM) and spunbond/meltblown/spunbond (SMS) laminate fabrics, and may also be used in combination with thermoplastic films. Nonwoven fabrics may also be bonded, embossed, treated and/or colored to impart various desired properties, depending on end-use application.

Melt extrusion processes for spinning continuous filament yarns and continuous filaments or fibers such as spunbond fibers, and for spinning microfibers such as meltblown fibers, and the associated processes for forming nonwoven webs or fabrics

therefrom, are well known in the art. Typically, fibrous nonwoven webs such as spunbond nonwoven webs are formed with the fiber extrusion apparatus, such as a spinneret, and fiber attenuating apparatus, such as a fiber drawing unit (FDU), oriented in the cross-machine direction or "CD". That is, the apparatus is oriented at a 90 degree angle to the direction of web production. The direction of nonwoven web production is known as the "machine direction" or "MD". Although the fibers are laid on the forming surface in a generally random manner, still, because the fibers exit the CD oriented spinneret and FDU and are deposited on the MD-moving forming surface, the resulting nonwoven webs have an overall average fiber directionality wherein more of the fibers are oriented in the MD than in the CD. It is widely recognized that such properties as material tensile strength, extensibility and material barrier, for example, are a function of the material uniformity and the directionality of the fibers or filaments in the web. Various attempts have been made to distribute the fibers or filaments within the web in a controlled manner, attempts including the use of electrostatics to impart a charge to the fibers or filaments, the use of spreader devices to direct the fibers or filaments in a desired orientation, the use of mechanical deflection means for the same purpose, and reorienting the fiber forming means. Electrostatic charging devices are known in the art. Generally described, an electrostatic charging device may have one or more rows of electric emitter pins or bars which produce a corona discharge, thereby imparting an electrostatic charge to the fibers. The fibers, once charged, will tend to repel one another and help prevent groups of individual fibers from clumping or "roping" together. An exemplary process for charging fibers to produce nonwovens with improved fiber distribution is disclosed in co-assigned PCT Pub. No. WO 02/52071 published July 04, 2002. However, it remains desired to achieve still further capability to gain this control in a way that is consistent with costs dictated by the disposable applications for many of these nonwovens.

Summary of the Invention

The present invention provides an improved process of using electrostatics in the formation of nonwoven webs. In the process of the present invention, a source of fibers is provided. The fibers and filaments are subject to an electrostatic charge which is generated via an electrostatic unit having a first side and a second side opposed to each other, wherein the electrostatic unit has an array of protrusions on both the first side and the second side of the electrostatic unit. Once subject to the electrostatic charge, the fibers are collected on a forming surface to form a nonwoven web.

The present invention also provides an apparatus for forming a nonwoven web. The apparatus of the present invention has a source of fibers, a device for applying an

electrostatic charge to said fibers, wherein the device having a first side and a second side opposed to each other, wherein the device has an array of protrusions on the first side and the second side of the device; and a forming surface for collecting said fibers.

Brief Description of the Drawings

Figure 1 shows a schematic illustration of an exemplary process for process for producing a nonwoven web.

Figures 2 A and 2B each show an exemplary device for applying an electrostatic charge to the fibers.

Figure 3 shows an exemplary device for applying an electrostatic charge to the fibers.

Definitions

As used herein and in the claims, the term “comprising” is inclusive or open-ended and does not exclude additional unrecited elements, compositional components, or method steps.

As used herein the term “polymer” generally includes but is not limited to, homopolymers, copolymers, such as for example, block, graft, random and alternating copolymers, terpolymers, etc. and blends and modifications thereof. Furthermore, unless otherwise specifically limited, the term “polymer” shall include all possible geometrical configurations of the material. These configurations include, but are not limited to isotactic, syndiotactic and random symmetries.

As used herein the term “fibers” refers to both staple length fibers and continuous fibers, also known as filaments, unless otherwise indicated.

As used herein the term “monocomponent” fiber refers to a fiber formed from one or more extruders using only one polymer. This is not meant to exclude fibers formed from one polymer to which small amounts of additives have been added for color, anti-static properties, lubrication, hydrophilicity, etc. These additives, e.g. titanium dioxide for color, are generally present in an amount less than 5 weight percent and more typically about 2 weight percent.

As used herein the term “multicomponent fibers” refers to fibers which have been formed from at least two component polymers, or the same polymer with different properties or additives, extruded from separate extruders but spun together to form one fiber. Multicomponent fibers are also sometimes referred to as conjugate fibers or bicomponent fibers. The polymers are arranged in substantially constantly positioned distinct zones

across the cross-section of the multicomponent fibers and extend continuously along the length of the multicomponent fibers. The configuration of such a multicomponent fiber may be, for example, a sheath/core arrangement wherein one polymer is surrounded by another, or may be a side by side arrangement, an “islands-in-the-sea” arrangement, or arranged as pie-wedge shapes or as stripes on a round, oval, or rectangular cross-section fiber. Multicomponent fibers are taught in, for example, U.S. Pat. No. 5,108,820 to Kaneko et al., U.S. Pat. No. 5,336,552 to Strack et al., and U.S. Pat. No. 5,382,400 to Pike et al. For two component fibers, the polymers may be present in ratios of 75/25, 50/50, 25/75 or any other desired ratios.

As used herein the term “biconstituent fiber” or “multiconstituent fiber” refers to a fiber formed from at least two polymers, or the same polymer with different properties or additives, extruded from the same extruder as a blend and wherein the polymers are not arranged in substantially constantly positioned distinct zones across the cross-section of the multicomponent fibers. Fibers of this general type are discussed in, for example, U.S. Pat. No. 5,108,827 to Gessner.

As used herein the term “nonwoven web” or "nonwoven material" means a web having a structure of individual fibers or filaments which are interlaid, but not in an identifiable manner as in a knitted or woven fabric. Nonwoven webs have been formed from many processes such as for example, meltblowing processes, spunbonding processes, air-laying processes and carded web processes. The basis weight of nonwoven fabrics is usually expressed in grams per square meter (gsm) or ounces of material per square yard (osy) and the fiber diameters useful are usually expressed in microns. (Note that to convert from osy to gsm, multiply osy by 33.91).

As used herein, the term “spunbond" or "spunbond nonwoven web” means to a nonwoven fiber or filament material of small diameter fibers that are formed by extruding molten thermoplastic polymer as fibers from a plurality of capillaries of a spinneret. The extruded fibers are cooled while being drawn by an eductive or other well known drawing mechanism. The drawn fibers are deposited or laid onto a forming surface in a generally random manner to form a loosely entangled fiber web, and then the laid fiber web is subjected to a bonding process to impart physical integrity and dimensional stability. The production of spunbond fabrics is disclosed, for example, in U.S. Pat. Nos. 4,340,563 to Appel et al., 3,692,618 to Dorschner et al., and 3,802,817 to Matsuki et al. Typically, spunbond fibers or filaments have a weight-per-unit-length in excess of about 1 denier and up to about 6 denier or higher, although both finer and heavier spunbond fibers can be produced. In terms of fiber diameter, spunbond fibers generally have an average

diameter of larger than 7 microns, and more particularly between about 10 and about 25 microns, and up to about 30 microns or more.

As used herein the term "meltblown fibers" means fibers or microfibers formed by extruding a molten thermoplastic material through a plurality of fine, usually circular, die capillaries as molten threads or fibers into converging high velocity gas (e.g. air) streams which attenuate the fibers of molten thermoplastic material to reduce their diameter. Thereafter, the meltblown fibers are carried by the high velocity gas stream and are deposited on a collecting surface to form a web of randomly dispersed meltblown fibers. Such a process is disclosed, for example, in U.S. Pat. No. 3,849,241 to Buntin. Meltblown fibers may be continuous or discontinuous, are generally smaller than 10 microns in average diameter and are often smaller than 7 or even 5 microns in average diameter, and are generally tacky when deposited onto a collecting surface.

As used herein, "thermal point bonding" involves passing a fabric or web of fibers or other sheet layer material to be bonded between a heated calender roll and an anvil roll. The calender roll is usually, though not always, patterned on its surface in some way so that the entire fabric is not bonded across its entire surface. As a result, various patterns for calender rolls have been developed for functional as well as aesthetic reasons. One example of a pattern has points and is the Hansen Pennings or "H&P" pattern with about a 30% bond area with about 200 bonds/square inch as taught in U.S. Pat. No. 3,855,046 to Hansen and Pennings. The H&P pattern has square point or pin bonding areas wherein each pin has a side dimension of 0.038 inches (0.965 mm), a spacing of 0.070 inches (1.778 mm) between pins, and a depth of bonding of 0.023 inches (0.584 mm). The resulting pattern has a bonded area of about 29.5%. Another typical point bonding pattern is the expanded Hansen and Pennings or "EHP" bond pattern which produces a 15% bond area with a square pin having a side dimension of 0.037 inches (0.94 mm), a pin spacing of 0.097 inches (2.464 mm) and a depth of 0.039 inches (0.991 mm). Other common patterns include a diamond pattern with repeating and slightly offset diamonds and a wire weave pattern looking as the name suggests, e.g. like a window screen. Typically, the percent bonding area varies from around 10% to around 30% of the area of the fabric laminate web. Thermal point bonding imparts integrity to individual layers by bonding fibers within the layer and/or for laminates of multiple layers, point bonding holds the layers together to form a cohesive laminate.

As used herein, the term "protrusions" means a structure which extends outward from another structure. The protrusions can extend into the fiber curtain passing through the electrostatics unit or can be recessed in a cavity such that they do not extend into the

fiber curtain, but extend from a structure with the cavity. In the present invention, the protrusions can be rods, bars, a wire, a loop of wire or pins.

As used herein, the term "array" means a matrix of protrusions. The matrix can be one row of protrusions extending the width of the cross machine direction of the process or a series of rows.

Detailed Description of the Invention

The present invention provides an improved process of using electrostatics in the formation of nonwoven webs. In the process of the present invention, a source of fibers is provided. The fibers are subject to an electrostatic charge which is generated via an electrostatic unit having a first side and a second side opposed to each other, wherein the electrostatic unit has an array of protrusions on both the first side and the second side of the electrostatic unit. Once subject to the electrostatic charge, the fibers are collected on a forming surface to form a nonwoven web.

The invention will be more fully described with reference to the Figures. Turning to FIG. 1, illustrated in schematic form in side view is an exemplary process for production of a nonwoven web material. As illustrated, spinplate 10 receives polymer from a conventional melt extrusion system (not shown) and forms fibers 12 which may be monocomponent, multicomponent (conjugate) or biconstituent fibers, as described above. The spinplate has openings (not shown) arranged in one or more rows. The spinplate opening form a downwardly extending "curtain" or "bundle" of fibers 12 when the polymer is extruded through the spinplate. Spinplates for extruding multicomponent continuous fibers are well known to those of ordinary skill in the art and thus are not described here in detail; however, an exemplary spinplate for producing multicomponent fibers is described in U.S. Patent No. 5,989,004 to Cook, the entire contents of which are herein incorporated by reference.

Polymers suitable for the present invention include the known polymers suitable for production of nonwoven webs and materials such as for example polyolefins, polyesters, polyamides, polycarbonates and copolymers and blends thereof. Suitable polyolefins include polyethylene, e.g., high density polyethylene, medium density polyethylene, low density polyethylene and linear low density polyethylene; polypropylene, e.g., isotactic polypropylene, syndiotactic polypropylene, blends of isotactic polypropylene and atactic polypropylene; polybutylene, e.g., poly(1-butene) and poly(2-butene); polypentene, e.g., poly(1-pentene) and poly(2-pentene); poly(3-methyl-1-pentene); poly(4-methyl-1-pentene); and copolymers and blends thereof. Suitable copolymers include random and block copolymers prepared from two or more different unsaturated olefin monomers, such as ethylene/propylene and ethylene/butylene copolymers. Suitable polyamides include

nylon 6, nylon 6/6, nylon 4/6, nylon 11, nylon 12, nylon 6/10, nylon 6/12, nylon 12/12, copolymers of caprolactam and alkylene oxide diamine, and the like, as well as blends and copolymers thereof. Suitable polyesters include polylactide and polylactic acid polymers as well as polyethylene terephthalate, poly-butylene terephthalate, polytetramethylene terephthalate, polycyclohexylene-1,4-dimethylene terephthalate, and isophthalate copolymers thereof, as well as blends thereof.

The exemplary process line in FIG. 1 also includes a quench blower 11 positioned adjacent the curtain of fibers 12 extending from the spinplate 10. Air from the quench air blower 11 quenches the fibers 12 extending from the spinplate 10. The quench air can be directed from one side of the fiber curtain 12 as shown in FIG. 1, or both sides of the fiber curtain 12. As used herein, the term "quench" simply means reducing the temperature of the fibers using a medium that is cooler than the fibers such as using, for example, chilled air streams, ambient temperature air streams, or slightly to moderately heated air streams. The process may desirably further comprise a means (not shown) to carry away fumes produced from the molten polymer such as a vacuum duct mounted above or otherwise near spinplate 10.

A fiber draw unit or aspirator 14 is position below the spin plate and the quench blower 11. The fiber draw unit or aspirator receives the quenched curtain of fibers 12. Fiber draw units or aspirators for use in melt spinning polymers are well known in the art. Suitable fiber drawing units for use in the method of the present invention include, for example, linear fiber aspirators of the types shown in U.S. Pat. No. 3,802,817 to Matsuki et al. and U.S. Pat. Nos. 4,340,563 and 4,405,297 to Appel et al., all herein incorporated by reference.

Generally described, the fiber drawing unit 14 includes an elongate vertical passage 15 through which the fibers are drawn by aspirating air entering from the sides of the passage and flowing downwardly through the passage. Aspirating air is supplied by a blower (not shown). The aspirating air may be heated or unheated. The aspirating air applies drawing forces on the fibers and pulls the fibers through the passage of the fiber drawing unit 14 and by the application of drawing forces attenuates the fibers, that is, reduces the diameter of the fibers. The aspirating air also acts to guide and pull the bundle of fibers through the attenuation chamber of the fiber drawing unit 14. Where multicomponent fibers in a crimpable configuration are used and where it is desired to activate latent helical crimp in the fibers prior to fiber laydown, the blower supplies heated aspirating air to the fiber drawing unit 14. In this respect, the heated aspirating air both attenuates the fibers and activates the latent helical crimp, as is described in U.S. Pat. No. 5,382,400 to Pike et al. When it is desired to activate the latent helical crimp in the fibers

at some point following fiber laydown, the blower supplies unheated aspirating air to fiber drawing unit 14. In this instance, heat to activate the latent crimp may be supplied to the web at some point after fiber laydown.

Generally, the fiber draw unit 14 includes chambers 16 which are supplied with air for the blower not shown. The aspirating air is directed from the chambers 16 at high velocity downward to pull the curtain of fibers 12, thereby causing orientation of the fibers, which often results in an increase in their strength properties. Below the fiber draw unit 14, there is shown electrostatics unit 18. The electrostatics unit includes rows 20 of protrusions on a first side of the electrostatics unit 18, and rows of protrusions 21 on a second side of the electrostatics unit 18. A potential or voltage is applied to the protrusions on one or both sides of the electrostatics unit via a power supply V1 or V2. The potential can be either a negative or positive potential, however, if a potential is applied to both sides of the electrostatics unit, then one side must have a positive potential and the other side must have a negative potential applied to the protrusions. This difference in potential charge is commonly referred to as a bias. Alternatively, one side of the electrostatic unit may be grounded and the other side will have a potential applied to the protrusions. When one side is grounded, it is not critical if the potential is negative or positive. As shown in FIG 1, the protrusions 20 produce a corona discharge against row of protrusions 21, resulting in an electrostatic charge being placed on the fibers. Once charged, the fibers tend to repel one another, thereby preventing groups of individual fibers from clumping or "roping" together. The configuration of the electrostatics unit of the present invention will be given in further detail below, and can be different from that which is shown in FIG 1. Further possible configurations will be shown in FIG 2 and FIG 3.

Shown below the electrostatic unit 18 is an optional mechanical deflector 24 which helps distribution of the fibers. The mechanical deflector may be replaced with a non-contacting deflector, such as the one described in U.S. Patent Application No. ______, filed concurrently herewith, assigned to the assignee of the present application (Attorney docket number 18242) and is hereby incorporated by reference. In this patent application, described is a non-contacting deflecting device comprises an air jet deflector providing discrete jets of air. The deflector is an optional attachment below the electrostatics unit. That is, the deflector are not needed in the process of the present invention.

The charged filaments 12' then are directed to the forming wire 26 moving around rolls 28, one or both of which may be driven with a motor (not shown). A compaction device, such as air knife 30, may be used to consolidate web 32 prior to bonding nip 34 between calender rolls 36, 38 (one or both of which may be patterned as described above) which form bonded web 40. Other methods of bonding the resulting nonwoven web, such as

through air bonding may also be used in the process of the present invention in place of the compaction device. If desired, a conventional means 35 for removing or reducing the charge on the web may optionally be employed such as applying an oppositely charged field or ion cloud.

Turning to FIG. 2A, an electrostatic unit arrangement 201 useful in the present invention is shown in a side view. The electrostatic unit arrangement has a first array of electrodes 210 on a first side of the electrostatic unit 201 and a second array of electrodes 220 on a second side of the electrostatic unit, wherein the electrodes are opposed to one another. As shown, the electrode arrays 210 and 220, each have a series of multiple bars extending substantially along the cross-machine width of the fiber draw unit, for example four bars 212, 214, 216 and 218 associated with the first array of electrodes 210 and four bars 222, 224, 226, and 228 associated with the second array of electrodes, each with a plurality of protrusions 211. The protrusions can be rods, loops, including loops or wire or pins and are desirable emitter pins 211. The bars in each array are held in place by an electrically insulating material 205, which also serves to isolated the electrostatic unit from the other equipment of the process, such as the fiber draw unit. Each of the charge bars is attached to a power supply 230, or is in the alternative grounded, if the pins 211 on the other side of the electrostatic unit 201 are connected to a power supply.

Also as is shown in FIG 2A, the emitter pins 211 are desirable recessed within the insulation material to prevent the fibers from fouling the emitter pins. Fouling of the emitter pins can be caused by the fibers catching on the emitter pins since the pins have relatively sharp tips to better generated the electrostatic charge.

Turning to Figure 2B, another electrostatic unit arrangement 251 useful in the present invention is shown in a side view. The electrostatic unit arrangement has a first array of electrodes 210 and a third array of electrodes 260 on a first side of the electrostatic unit 201 and a second array of electrodes 220 and a fourth array of electrodes 270 on a second side of the electrostatic unit. As shown, the electrode arrays 210, 220, 260 and 270 each have a series of multiple bars extending substantially along the cross-machine width of the fiber draw unit, for example four bars 212, 214, 216 and 218 associated with the first array of electrodes 210 and four bars 222, 224, 226, and 228 associated with the second array of electrodes 220, four bars 262, 264, 266 and 268 associated with the third array of electrodes 260 and four bars 272, 274, 276, and 278 associated with the fourth array of electrodes 270 each with a plurality of protrusions 211, which are desirable emitter pins 211. The bars are held in place by an electrically insulating material 205, which also serves to isolated the electrostatic unit from the other equipment of the process, such as the fiber draw unit and the electrodes of the previous section of the electrostatic unit. Each of the

charge bars is attached to a power supply 230 or 231, or is, in the alternative, grounded, if the pins 211 on the other side of the electrostatic unit 201 is connected to a power supply.

As shown in FIG 2A and FIG 2B, the protrusions are on either side of the electrostatic unit and are opposed to each other. The electrostatic charge is generated between the protrusions or emitter pins.

FIG 3 shows yet another electrostatic unit arrangement 351 useful in the present invention shown in a side view. The electrostatic unit arrangement such that a first section has a first array of electrodes 310 on a first side of the electrostatic unit 351. This array of electrodes has a series of multiple bars extending substantially along the cross-machine width of the fiber draw unit, for example four bars 312, 314, 316 and 318 associated therewith, each with a plurality of protrusions 311. The bars are connected to a power supply 330 which provides a potential or voltage to the pins. On a second side of the electrostatic unit, directly across from the array of electrodes 311 is a target 319, which is shown to be grounded. In the alternative the target 319 may also be attached to a power supply, provided that a bias is established, as is stated above. In FIG 3, the protrusions on the first side and the second side are offset and are not directly opposed to one another. The bars in each array are held in place by an electrically insulating material 305, which also serves to isolate the electrostatic unit from the other equipment of the process, such as the fiber draw unit. In addition, the insulation material 305 insulates the first section of the electrostatic unit from other sections of the electrostatic unit. In a second section of the electrostatic unit, this section has a second array of electrodes 320 on a second side of the electrostatic unit 351. This array of electrodes has a series of multiple bars extending substantially along the cross-machine width of the fiber draw unit, for example four bars 322, 324, 326 and 328 associated therewith, each with a plurality of protrusions 311, shown as pins 311.The bars are attached to a power supply 330 On the first side of the electrostatic unit, directly across from the array of electrodes is a target 329. Like the first section of the electrostatic unit, the bars of the second section are held in place by an electrically insulating material 305, which also serves to isolate the second section of the electrostatic unit from the first section and an optional third section. In addition, a power supply is connected to the bars, hence the protrusions 320 and the target is shown to be grounded, but also may be attached to a power supply. In an optional third section of the electrostatic unit, this section has a third array of electrodes 360 on a first side of the electrostatic unit 351. This array of electrodes has a series of multiple bars extending substantially along the cross-machine width of the fiber draw unit, for example four bars 362, 364, 366 and 368 associated therewith, each with a plurality of protrusions 311. On the second side of the electrostatic unit, directly across from the array of electrodes is a target 369. Like the first and second sections of the

electrostatic unit, the bars of the third section are held in place by an electrically insulating material 305, which also serves to isolate the third section of the electrostatic unit from the second section and an optional additional sections of the electrostatics unit and the bars are connected to a power supply. Additional sections can be added below the optional third section, provided that the array of electrodes is on the opposite side of the previous section of the electrostatics unit.

The protrusions of the present invention of the electrostatic unit may be a pin, a rod, a wire or a looped wire. Desirably, the protrusions are pins, most desirably emitter pins. An exemplary emitter pin configuration usable in the present invention is one where the emitter pins are spaced apart at ¼ inch, and recessed at 1/8 inch in a cavity of 0.5 inch high x 0.25 inch deep. The actually spacing of the pins is not critical to the present invention and can be varied to achieve the desired corona discharge. The pins are typically arranged in rows which can be as wide or slightly wider than the fiber draw unit. Further, it is desirable, but not required, that the emitter pins are recessed. It has been discovered that fouling of the pins occurs to a lesser degree when the pins are recessed to a small degree in the insulation material which holds the pins in place, as compared to having the pins extend into the fiber curtain.

The protrusions can be stacked in several rows. As shown in the figures, there are 4 rows of the pins stacked on top of each other. This is not required, and the electrostatic unit can have a single row of protrusions of pins or several rows, for example, any where from 2-50 rows or more. The actual number of rows is limited by the height available from the fiber draw unit to the forming surface.

In the aspect of the electrostatic unit shown in FIG 3, the target plate is prepared from conductive material and will typically have a height and width approximately the same as the height and width of the protrusions or pins, whether unstacked or stacked. Typically, the size of the target plate varies depending on factors such as the width of the drawing slot. Generally, the target plate is prepared from conducting steel.

Using an electrostatic unit having an array of protrusions described above provides advantages over prior art electrostatic units. Advantages include, the ability to create greater currents at a given applied voltage, the ability to alternate the current from one side of the electrostatics unit to the other, and the ability to set the protrusions within a cavity to prevent fouling without reducing the size of the passage of the electrostatics unit, among others.

In addition, the present invention provides stacking of the electrostatics generating protrusions in several different and isolated sections, such as is shown in FIG 2B. This allows for longer running times before the fiber production unit must be shut down due to

fouling of the protrusions. Having stacked sections as shown in FIG 2B and FIG 3, each section of the unit may be run independent of the others. Therefore one section of the unit may be switched off, while another section is operating. As the operation section becomes fouled, and loses its ability to generate an acceptable current, the operation section of the electrostatic unit may be shut down and a different section be operated to generate the electrostatics.

In a further embodiment of the present invention, the electrostatics unit shown in FIG 2B and FIG 3 can be operated such that the current in the first section is in the direction of the first side to the second side of the electrostatics unit and the current in the next section is in the direction of the second side to the first side. For example, this can be accomplished by grounding the protrusions of the second side of the first section of the electrostatics unit and grounding the protrusions on the first side in the second section of the electrostatics unit, as shown in FIG 2, or visa verso. In FIG 3, the plates can be ground. As another alternative, the protrusions on the first side of the first section can have a negative or positive potential applied thereto and the opposite potential applied to the protrusions on the second side of the first section. In the next section, of the electrostatic unit, the potential can be set opposite that of the first section. In additional sections, if present, the potential is set such that the current is in a direction opposite of the previous section. This allows the fibers in the electrostatic unit to be charged on both sides and causes the fibers to flap back and forth from side to side, thereby causing and improved formation of the nonwoven web.

In a even further embodiment, the polarity of the electrostatics unit in any operating section can be reversed at high frequency from first side to the second side and the second side to the first side to flap fibers from the first to second side of the electrostatic unit or the second to the first side of the electrostatic unit. For example in FIG 1, the potential of V1 is switched form negative to positive at the same time the potential of V2 is switched from positive to negative. This will also tend to improve the formation of the resulting nonwoven web.

Examples

While the invention will be illustrated by means of examples, the examples are only representative and not limiting on the scope of the invention which is determined in reference to the appended claims.

An electrostatic unit was prepared having emitter pins spaced apart at 0.25 inch, and recessed at 0.125 inch in a cavity of 0.5 inch high x 0.25 inch deep on a first. A 26 inch wide rows (24 effective inch) of pins was prepared. The row of pins was manufactured by Tantec Inc. 630 Estes Avenue, Schaumburg, IL 60193. These pins were

connected to a high voltage DC source through a single 100 mega ohm resistor to measure the discharge current via the corresponding voltage. The power supply was Model EH3OR3, 0 - 30 KV, 0 - 3 MA, 100 watt regulated, reversible with respect to chassis ground, but the negative voltage was applied here although opposite charge may also be used. It was manufactured by Glassman High Voltage, Inc., P0 Box 551, Route 22 East, Salem Park, Whitehouse Station, NJ 08889.

On a second side of the electrostatics unit, directly opposite the emitter of the first side are emitter pins having the same configuration as the emitter pins of the first side. The pins of the second side were connected to another power supply through another 100 mega-ohm resistor. The power source was the same Glassman power supply, but with different, positive sign, polarity grounded rather than connected to the power supply.

The emitter pins of the first side of the unit and the second side of the unit were set such that the emitter pins were 0.7 inch and 1.2 inches apart from one another. The current between the emitter pins of the first side and the emitter pins of the second side was measured from the grounded second side at various voltages shown in Table 1.

In a second experiment, two rows of emitter pins having the same configuration as described above, were stacked such that the pins of the first row were approximately about 0.75 inch apart from the pins of the second row. The second side of the electrostatics unit also had two rows of pins such that the first row was 0.75 inch apart from the pins of the second row. The two rows of pins on the first side were connected to a power supply and the pins on the second side were connected to another power supply through another 100 mega-ohm resistor. The power source was the same Glassman power supply, but with different, positive sign, polarity were grounded. The current between the emitter pins of the first side and the emitter pins of the second side was measured from the grounded side at various voltages shown in Table 1.

As a comparison, the emitter pins of the second side were replaced with a target plate. The target plate was approximately 3 inches high x 26 inches wide and was prepared from an electrically conducting steel plate t, while the corresponding value of the uncoated steel resistance was close to 0.0002 ohms. The target plate was connected to another power supply through another 100 mega-ohm resistor. The power source was the same Glassman power supply, but with different, positive sign, polarity. The emitter pins of the first side of the unit and the target plate of the unit were set such that the emitter pins were 0.6 inch and 1.1 inches away from the target. The current between the emitter pins of the first side and the target plate of the second side was measured from the grounded second side at various voltages shown in Table 1.

Table 1

	Current for single row of emitter pins on both sides at distance (mA)		Current for two rows of emitter pins on both sides at distance (mA)		Current for emitter pins with target plate electrode at distance (mA) (Comparative)	
Voltage (kV)	0.7 in	1.2 in	0.7 in	1.2 in	0.6 in	1.1 in
15	0.211	0.093	0.354	0.150	0.149	0.0
16	0.240	.0.114	0.399	0.176	0.177	0.004
17	0.276	0.135	0.450	0.205	0.212	0.020
18	0.318	0.163	0.500	0.236	0.308	0.037
19	0.361	0.180	0.560	0.302	0.294	0.051
20	0.400	0.206	0.636	0.340	0.333	0.067
21	0.444	0.232	0.710	0.385	0.380	0.084
22	0.490	0.263	0.775	0.422	0.412	0.100
23	0.536	0.290	0.850	0.468	0.463	0.114
24	0.580	0.319	0.920	0.513	0.506	0.133
25	0.629	0.353	0.992	0.560	0.560	0.150

It is noted that in Table 1, the comparative example has the target plate at a shorter distance from the emitter pins than the Examples within the present invention. This is due to the fact that the emitter pins of the present invention are recessed within the cavity of the insulating material. In any event, as can be clearly seen in Table 1, the current generated at a given voltage is greater when emitter pins are used as the target instead of the target plate. Further, the current generated can also be increased by using additional rows of emitter pins on both sides of the electrostatics device.

The electrostatics unit described in the above Example above may be used in a process of producing a nonwoven fabric, as shown in Figure 1. Using the arrangement described herein, improve web formation can be obtained using lower voltages. Further, using pins on both sides of the electrostatics units gives the ability to alternate the potential across in order to cause the fibers to move side to side within the electrostatics unit.

The nonwoven web materials produced with the process of the present invention may be used alone or may be used in a laminate that contains at least one layer of

nonwoven web and at least one additional layer such as a woven fabric layer, an additional nonwoven fabric layer, a foam layer or film layer. The additional layer or layers for the laminate may be selected to impart additional and/or complementary properties, such as liquid and/or microbe barrier properties. The laminate structures, consequently, are highly suitable for various uses including various skin-contacting applications, such as protective garments, covers for diapers, adult care products, training pants and sanitary napkins, various drapes, surgical gowns, and the like. The layers of the laminate can be bonded to form a unitary structure by a bonding process known in the art to be suitable for laminate structures, such as a thermal, ultrasonic or adhesive bonding process or mechanical or hydraulic entanglement processes.

As an example, a breathable film can be laminated to the nonwoven web to provide a breathable barrier laminate that exhibits a desirable combination of useful properties, such as soft texture, strength and barrier properties. As another example the nonwoven web can be laminated to a non-breathable film to provide a strong, high barrier laminate having a cloth-like texture. These laminate structures provide desirable cloth-like textural properties, improved strength properties and high barrier properties. Another laminate structure highly suitable for the present invention is the spunbond-meltblown-spunbond laminate material such as is disclosed in U.S. Pat. No. 4,041,203 to Brock et al., which is herein incorporated in its entirety by reference.

The nonwoven web materials made by the present invention are highly suitable for various uses, such as for example uses including disposable articles, e.g., protective garments, sterilization wraps, surgical garments, and wiper cloths, and liners, covers and other components of absorbent articles.

While the invention has been described in terms of its best mode and other embodiments, variations and modifications will be apparent to those of skill in the art. It is intended that the attached claims include and cover all such variations and modifications as do not materially depart from the broad scope of the invention as described therein.